



BRAZING

IN

SPACE

The next frontier...

BRAZING IN SPACE

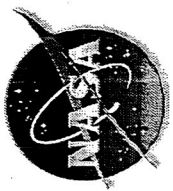


OUTLINE

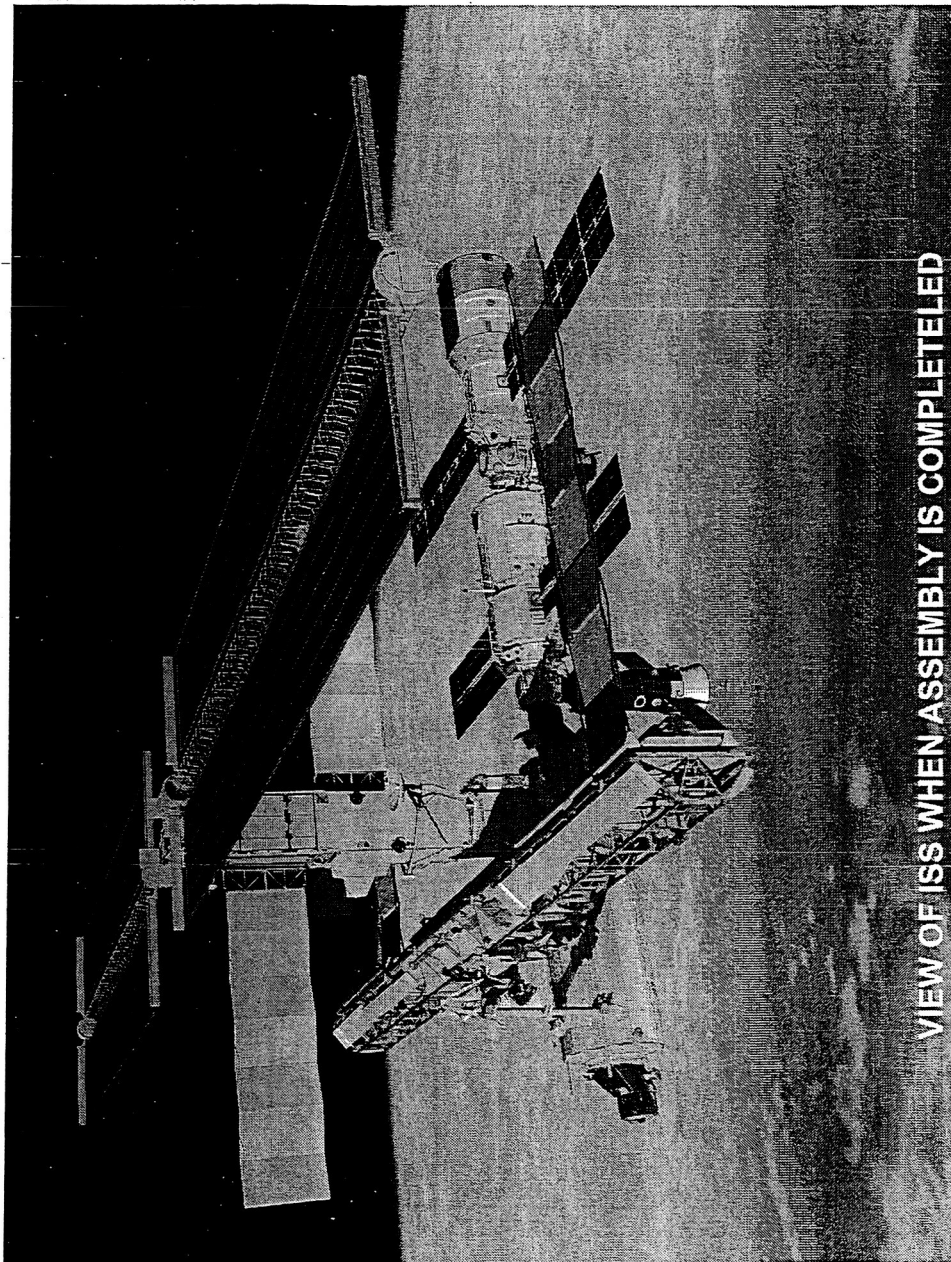
- **WHY DO WE NEED TO JOIN COMPONENTS IN SPACE**
- **WHY BRAZING?**
- **HISTORY OF BRAZING IN SPACE**
- **ELECTRON BEAM VACUUM BRAZING**
- **CURRENT EFFORT AT GSFC**
- **FUTURE WORK**

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BRAZING IN SPACE



•WHY DO WE NEED TO JOIN COMPONENTS IN SPACE



VIEW OF ISS WHEN ASSEMBLY IS COMPLETED

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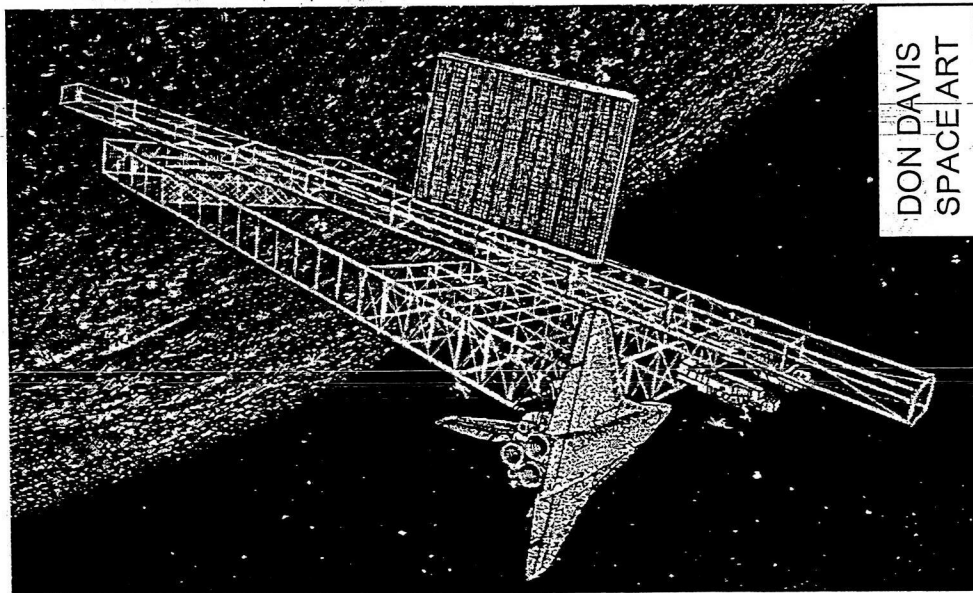
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BRAZING IN SPACE

• WHY DO WE NEED TO JOIN COMPONENTS IN SPACE



DON DAVIS
SPACE/ART



BOEING VISION OF ON-ORBIT CONSTRUCTION SITE FOR SPS

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BRAZING IN SPACE



• WHY DO WE NEED TO JOIN COMPONENTS IN SPACE

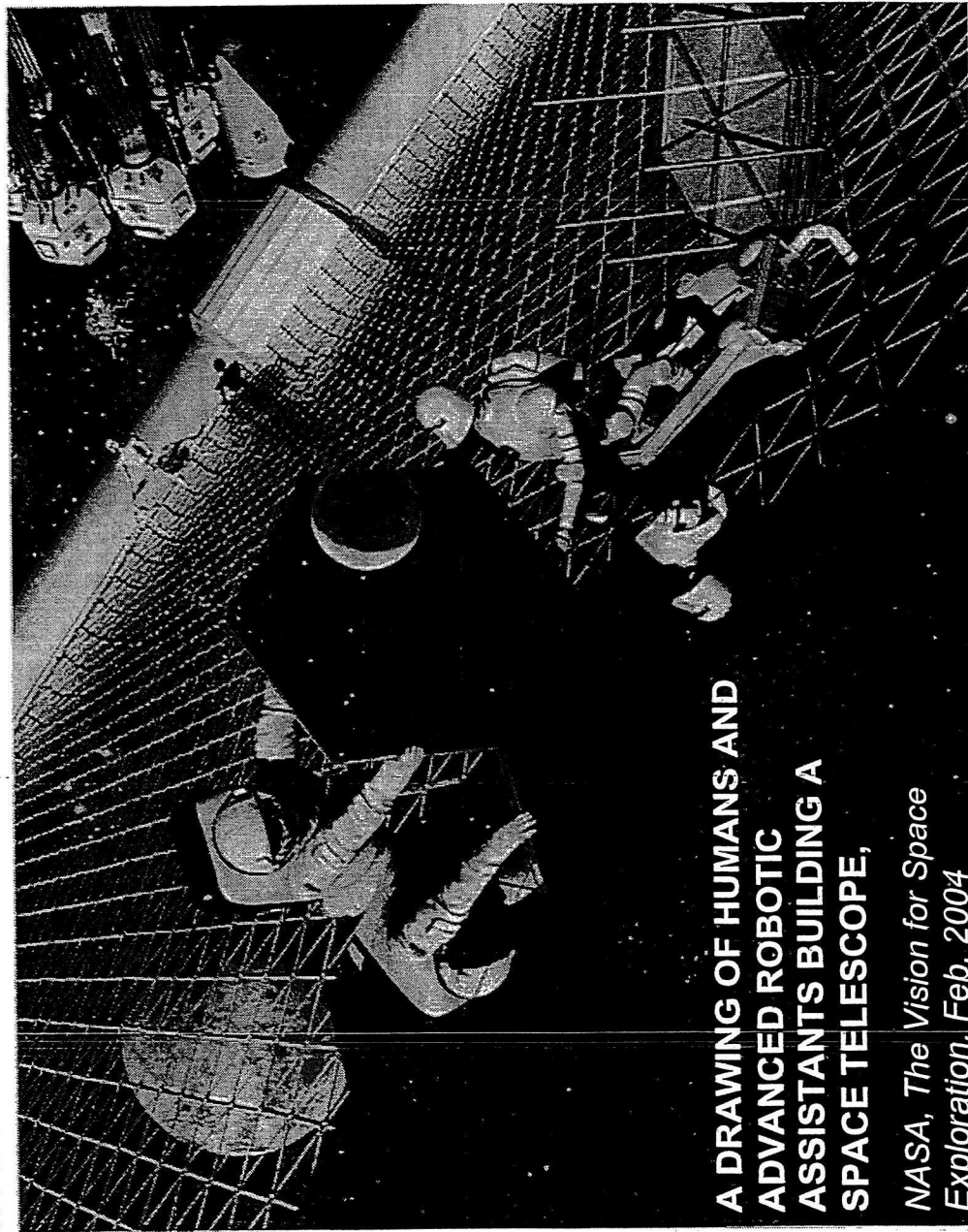
- In-space assembly can enable the deployment of large systems that cannot be accommodated in current or near-term launch vehicle payload provisions, whether limited by total mass, volume, density, or mission criticality.
- Risk mitigation and failure-intervention provisions, both for mission objectives and for humans space flight support, can be more readily accommodated on an assembly mission than on a build-and-deploy mission

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BRAZING IN SPACE

• WHY DO WE NEED TO JOIN COMPONENTS IN SPACE



**A DRAWING OF HUMANS AND
ADVANCED ROBOTIC
ASSISTANTS BUILDING A
SPACE TELESCOPE,**

*NASA, The Vision for Space
Exploration, Feb. 2004*

*"As for the future, your
task is not to see it, but to
enable it"*

Antoine de-Saint Exupery

4/27/2005

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•WHY BRAZING ?

STRUCTURAL JOINING PROCESSES:

- MECHANICAL JOINING**
- WELDING**
- ADHESIVE BONDING**
- BRAZING**

BRAZING IN SPACE



• WHY BRAZING ?

- NO SINGLE METHOD CAN SATISFY ALL JOINING NEEDS IN SPACE

- SELECTION OF JOINING METHOD DEPENDS ON:

- APPLICATION
- TYPE OF STRUCTURE
- MATERIALS



• WHY BRAZING ?

**OUR FOCUS IS ON CONSTRUCTION OF LARGE TRUSS
STRUCTURES IN SPACE:**

- TEDEIOUS AND SLOW PROCESS;
- CONSISTS OF A LARGE QUANTITY OF REPETATIVE STEPS;
- REQUIRES PERMANENT JOINTS

BRAZING IN SPACE



•WHY BRAZING ?

SPACE IS A NATURAL ENVIRONMENT FOR VACUUM BRAZING:

- no extra cost is required to create vacuum!
- does not depend on gravity - relies on capillary action
- molten metal is drawn into the joint interface
- joins any shape and any wall thickness
- generates no debris or fumes

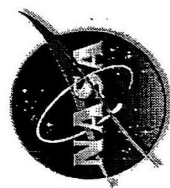
BRAZING IN SPACE



•WHY BRAZING ?

.... AND THE WINNER IS ...ELECTRON BEAM VACUUM BRAZING!

- ELECTRON BEAM IS A VERY FLEXIBLE, HIGHLY CONTROLLED METHOD OF DELIVERING PRECISE AMOUNT OF ENERGY TO A SPECIFIC LOCATION – BEAM CAN BE DEFLECTED, CHANGE SPOT SIZE, ACCELERATION VOLTAGE, PULSING, ROTATION – ALL BEAM MANIPULATIONS CAN BE DONE ELECTRONICALLY, I.E. NO MECHANICAL MOVEMENT IS REQUIRED!
- ELECTRON BEAM GUN IS A MATURE TECHNOLOGY, IDEALLY SUITED FOR SPACE ENVIRONMENT!
- IT HAS BEEN SUCCESSFULLY USED IN SPACE FOR WELDING, BRAZING, CUTTING AND METAL VAPOR DEPOSITION BY THE RUSSIAN COSMONAUTS.
- TRADE-OFF ANALYSIS SHOWS THAT EB BRAZING IS A BETTER CHOICE THAN LASER, RESISTANCE, INDUCTION OR EXOTHERMIC PROCESS



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BRAZING IN SPACE

• BRAZING EXPERIENCE IN SPACE

PLATFORM	MATERIALS BRAZED	BRAZE ALLOY	HEAT SOURCE	COMMENTS
Skylab Station, USA, 1973	Pure nickel tubes and sleeves, 304L stainless steel tubes and sleeves.	AWS BAg8a (71.8%Ag, 28% Cu and 0.2% Li)	Exothermic reaction	Excellent filler metal flow. Nice fillet formation. 0-g helps capillary action.
TEXUS II sounding rocket, Germany, 1978	Pure nickel cylinders	58%Ag, 39%Cu, 3% Li	Isothermal furnace	Extremely wide gaps of up to 2 mm could be filled under microgravity owing to capillary forces.
STS-9, Launch # 9, Columbia, USA, 1983	Nickel cylinders	AWS BAg8a	Isothermal Heating Facility	Microstructure was found to be independent on the gravitational level.
Solyut 7 Space station, USSR, 1984 - 1986	Thin wall nickel chromium alloy tubing plated with Ni to promote wetting.	Low melting alloy Sn-2Ni-4Ge developed at Paton Welding Institute.	Hand held Universal Electron Beam Gun	Good wetting and formation of fillets. After melting, pre-placed filler metal did not flow outside the joint gap. Much wider gaps can be filled under 0-g.
TR-IA sounding rocket, flight # 5, Japan, 1996	Stainless steel sleeves	Ag-Cu-Li alloy	Multipurpose furnace	Samples were subjected to isothermal and temperature gradient conditions. All joints showed complete penetration under microgravity. Future plans include additional metallurgical studies to develop basic data for structural construction in space.

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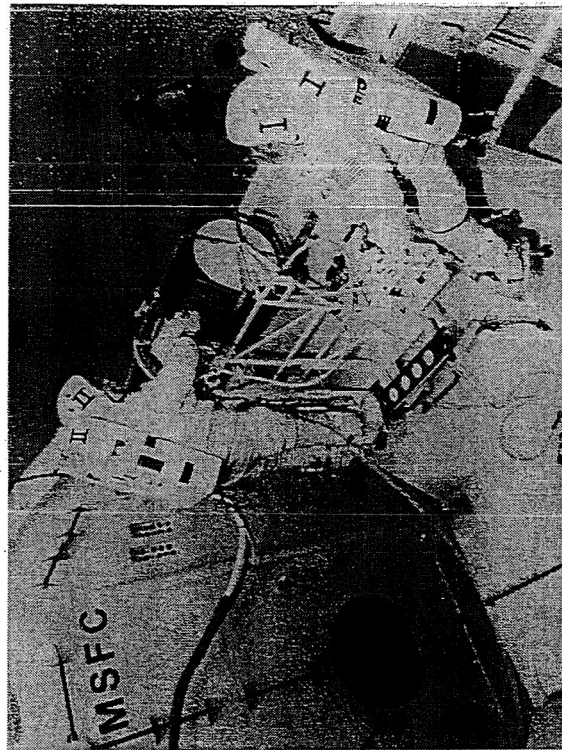
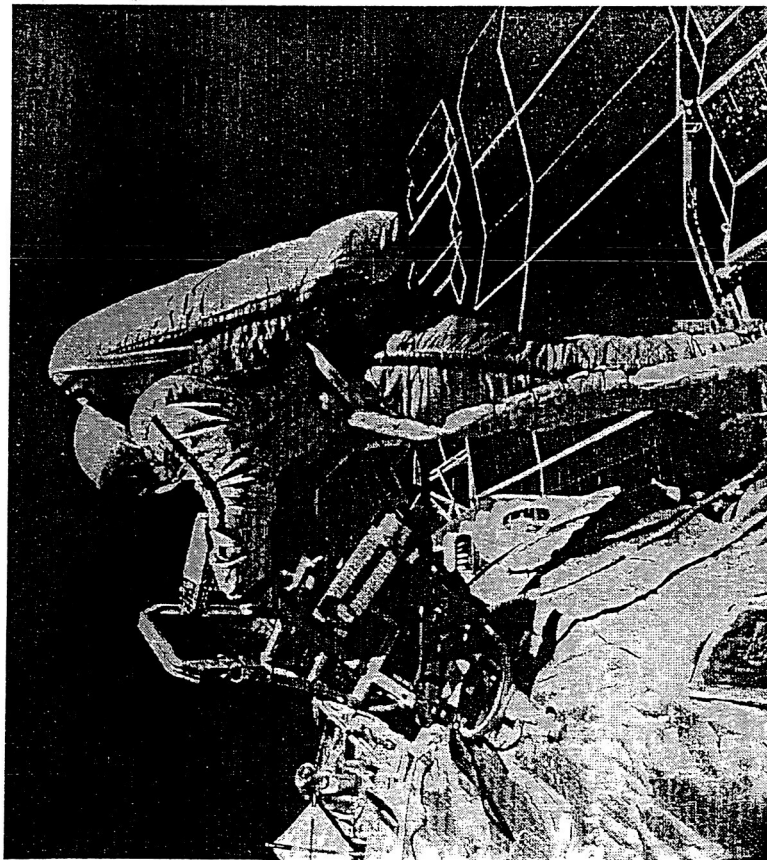
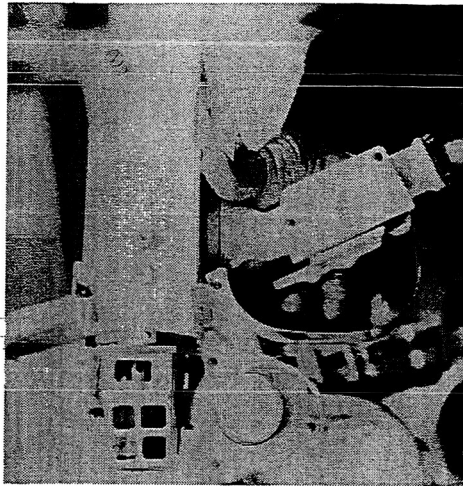
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• BRAZING EXPERIENCE IN SPACE



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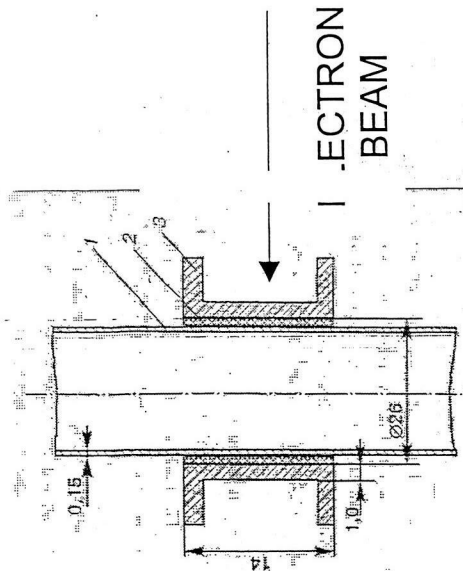
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• BRAZING EXPERIENCE IN SPACE

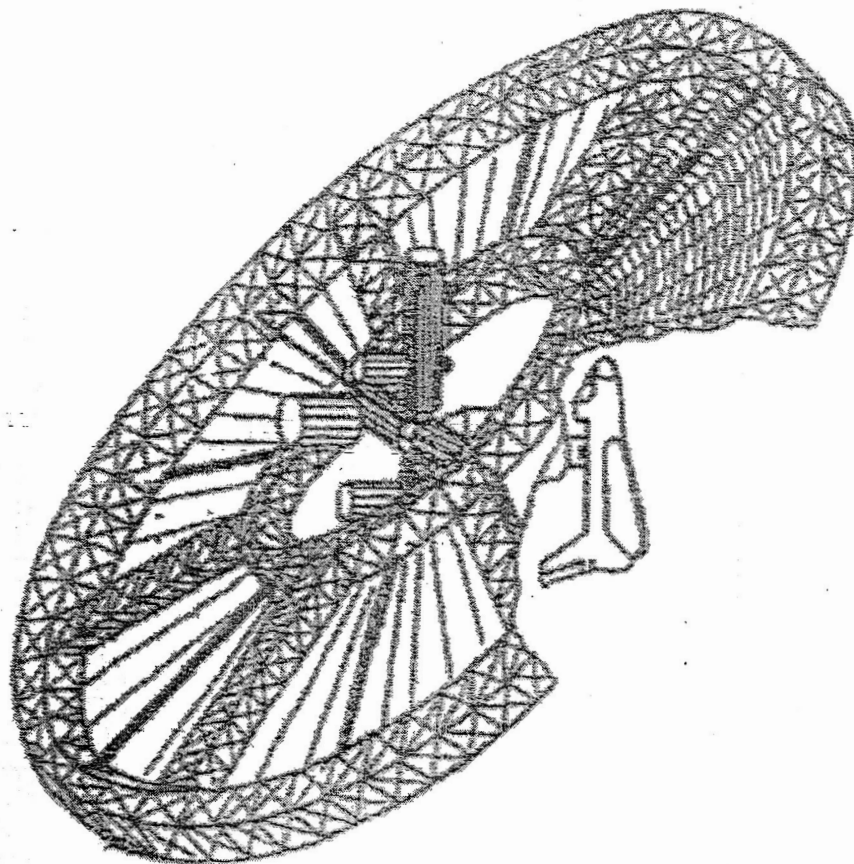
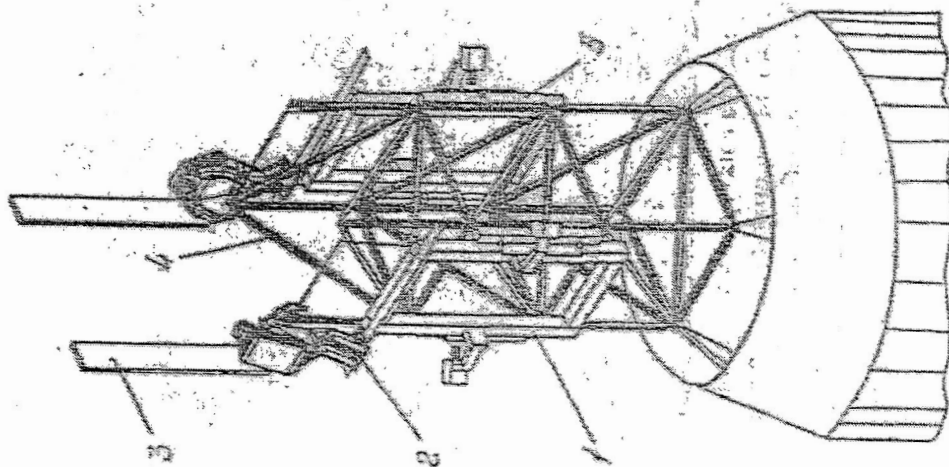
ELECTRON BEAM VACUUM BRAZING EXPERIMENT WAS PERFORMED
QUITE SUCCESSFULLY BY THE RUSSIAN COSMONAUTS IN OPEN SPACE
ON SALYUT-7 IN 1986.





BRAZING IN SPACE

• BRAZING EXPERIENCE IN SPACE – CONSTRUCTION OF "MIR-2"



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• ONGOING EFFORT AT GODDARD

IN-SPACE ROBOTIC INTEGRATION SYSTEM (IRIS)

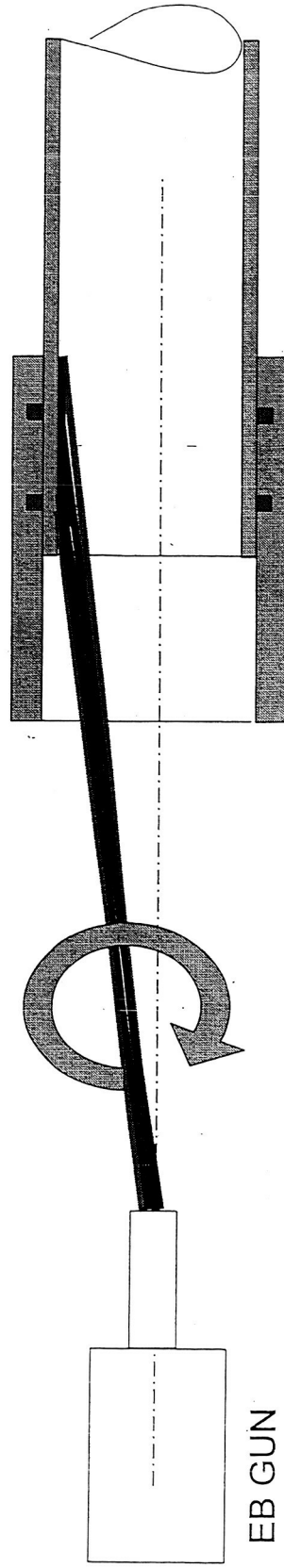
(initiated in 2005)

- BRAZING PROCESS
- BRAZEABLE TRUSS STRUCTURE
- AUTOMATION

BRAZING IN SPACE



- EFFORT AT GODDARD – brazing process



ROTATING ELECTRON BEAM IS APPLIED TO THE
INTERNAL SURFACE OF THE BRAZE JOINT

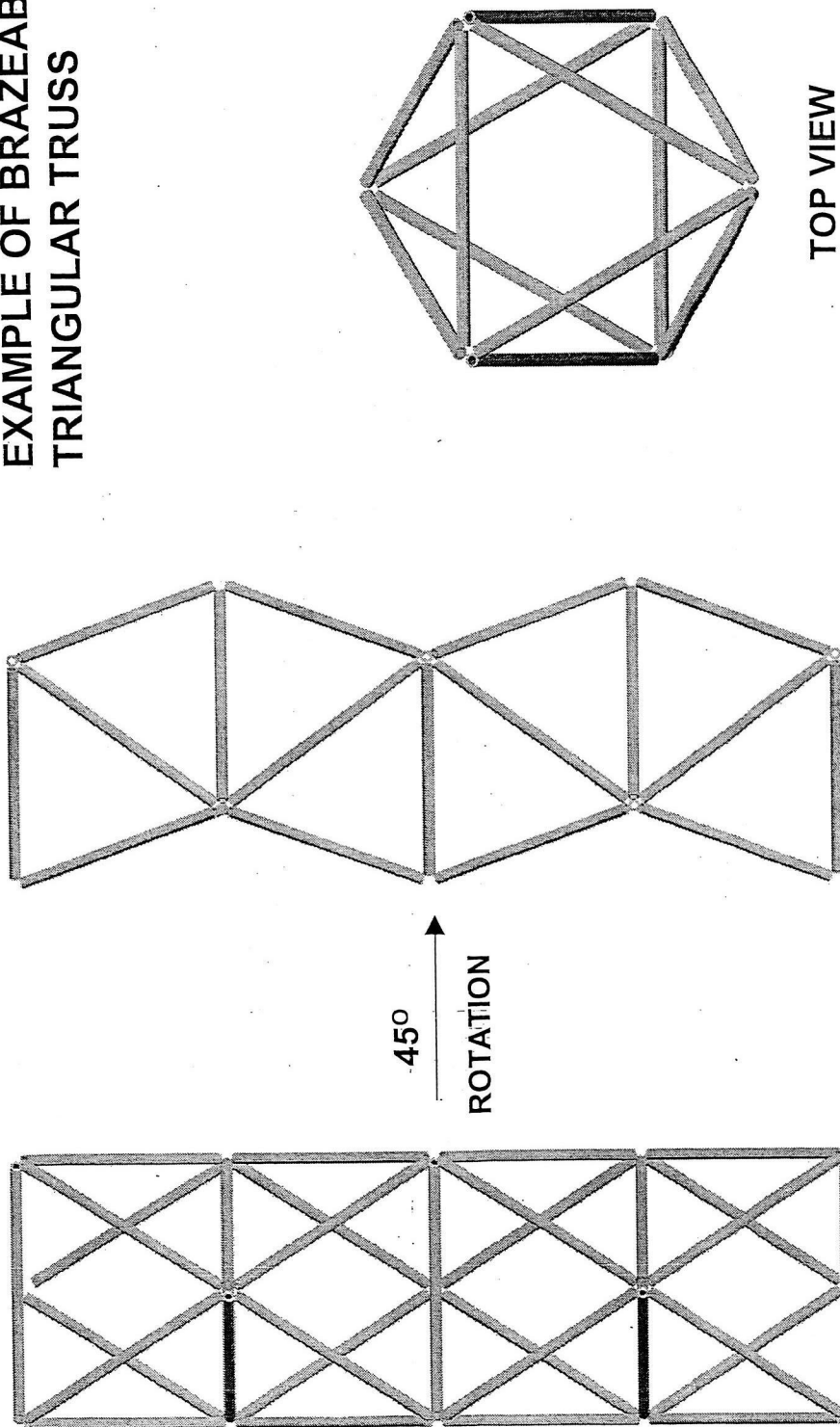


BRAZING IN SPACE

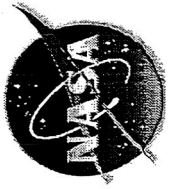
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- *EFFORT AT GODDARD – brazeable truss structure*

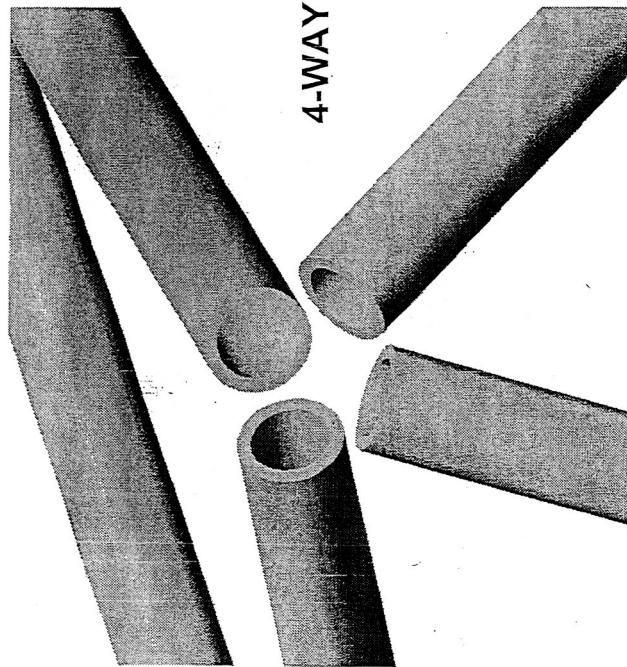
EXAMPLE OF BRAZEABLE TRIANGULAR TRUSS



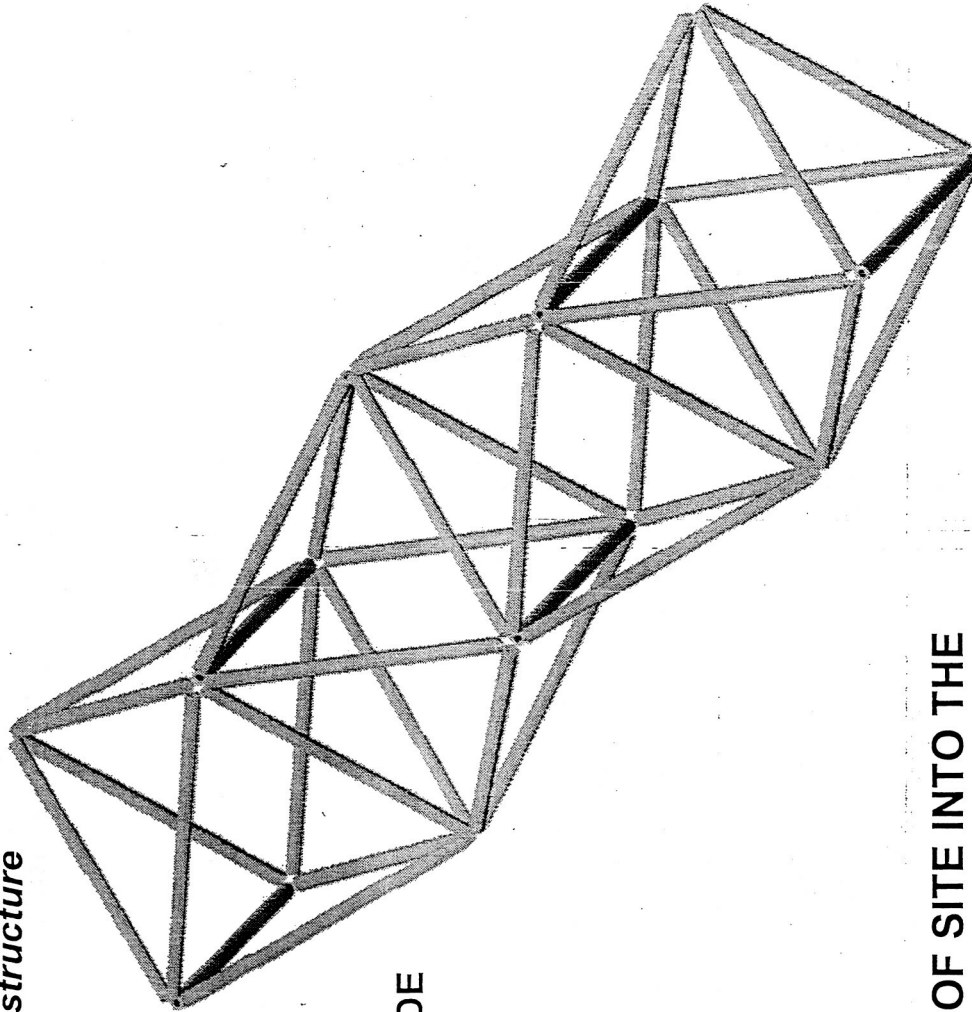
BRAZING IN SPACE



- *EFFORT AT GODDARD – brazeable truss structure*



4-WAY NODE



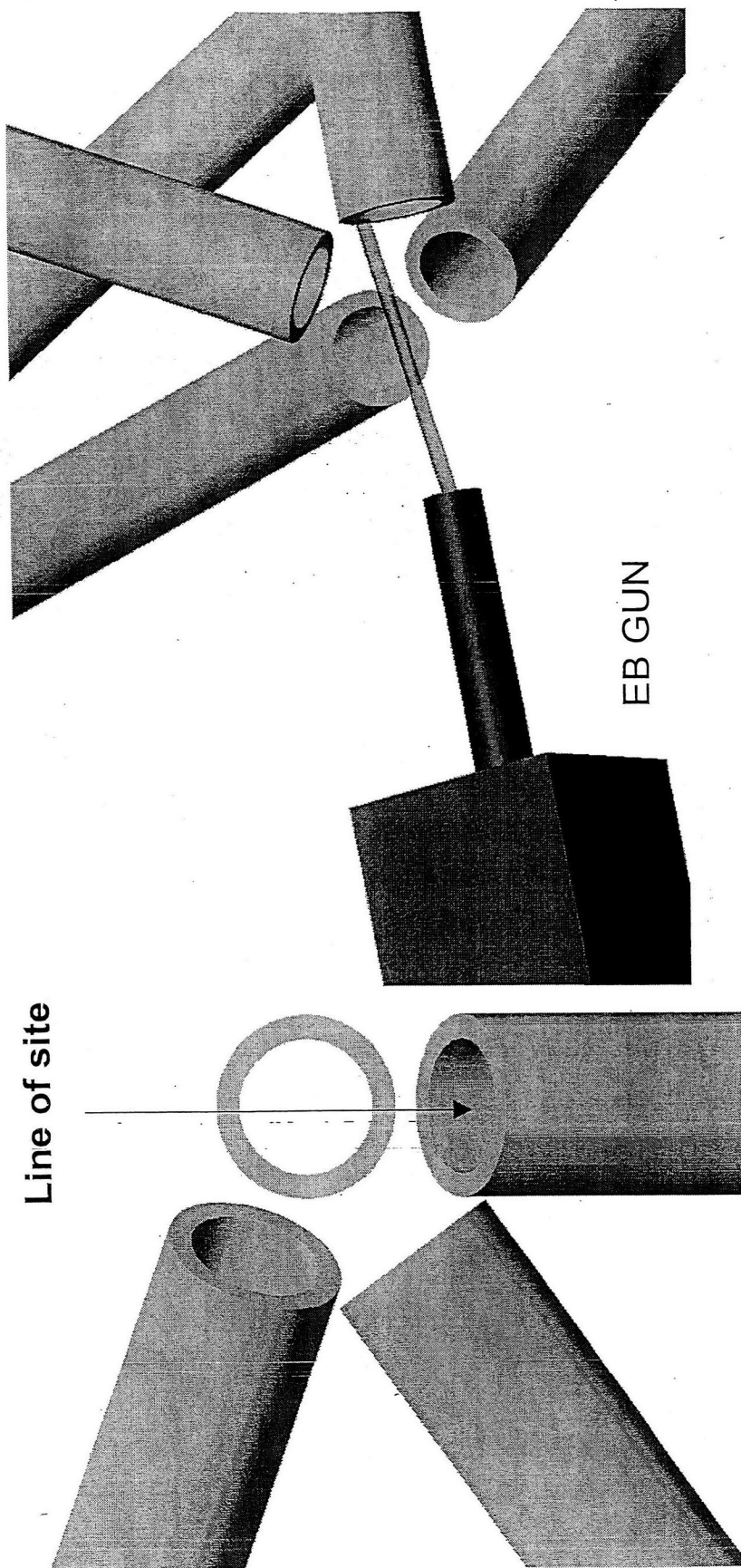
**ADVANTAGE OF THIS DESIGN:
PROVIDES UNOBSTRUCTED LINE OF SITE INTO THE
TUBULAR STRUT**



BRAZING IN SPACE

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- *EFFORT AT GODDARD – brazeable truss structure*



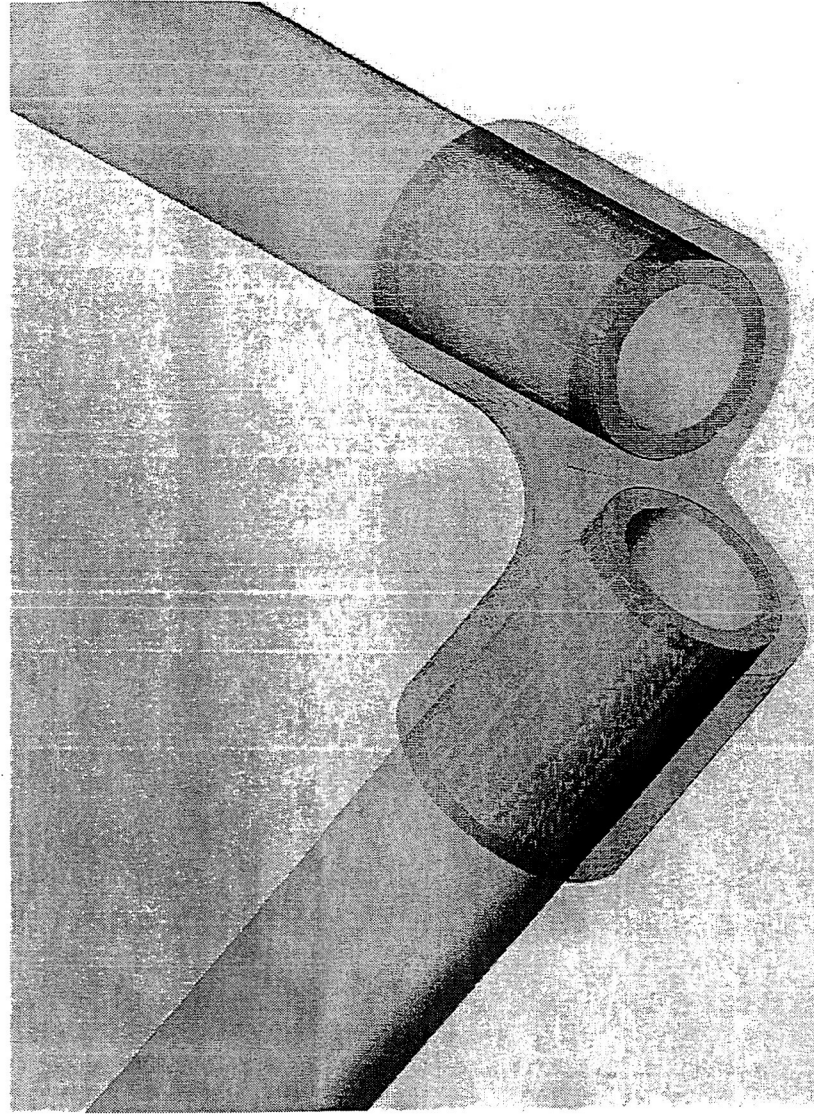
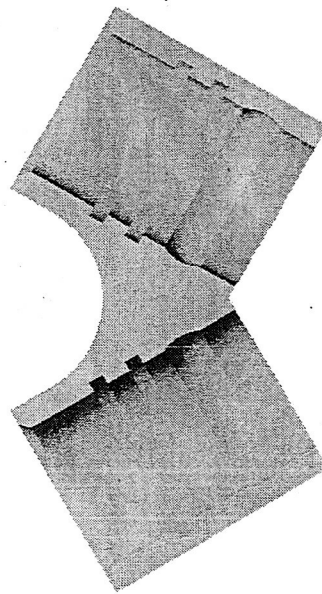
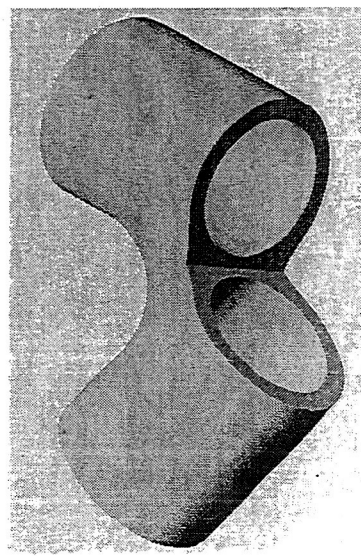
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BRAZING IN SPACE



- *EFFORT AT GODDARD – brazeable truss structure*

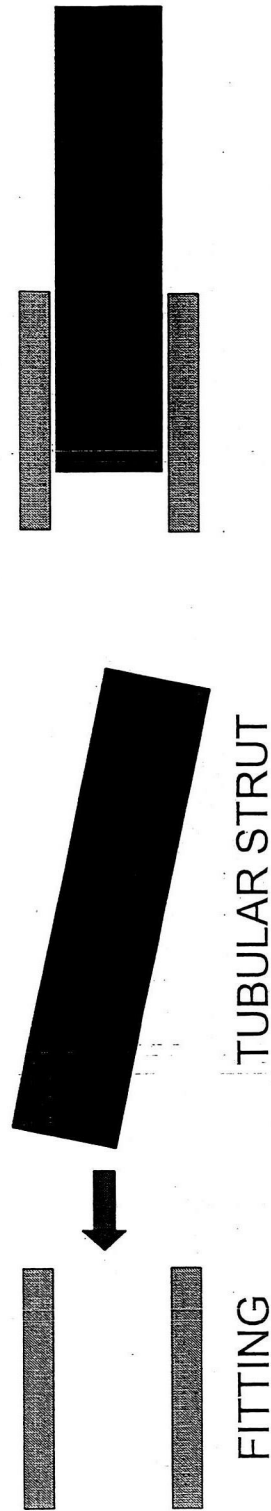


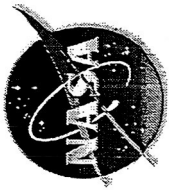
EXAMPLE OF 2-WAY "OPEN" FITTING



- *EFFORT AT GODDARD – robotics*

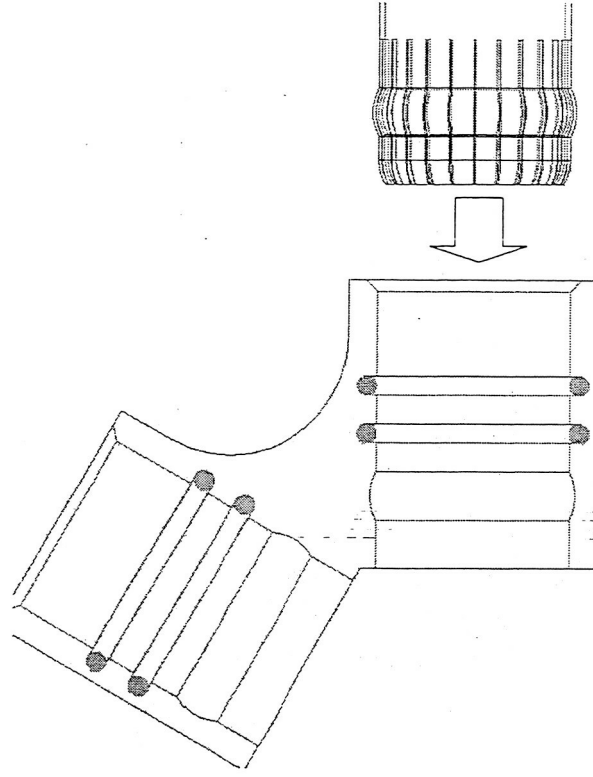
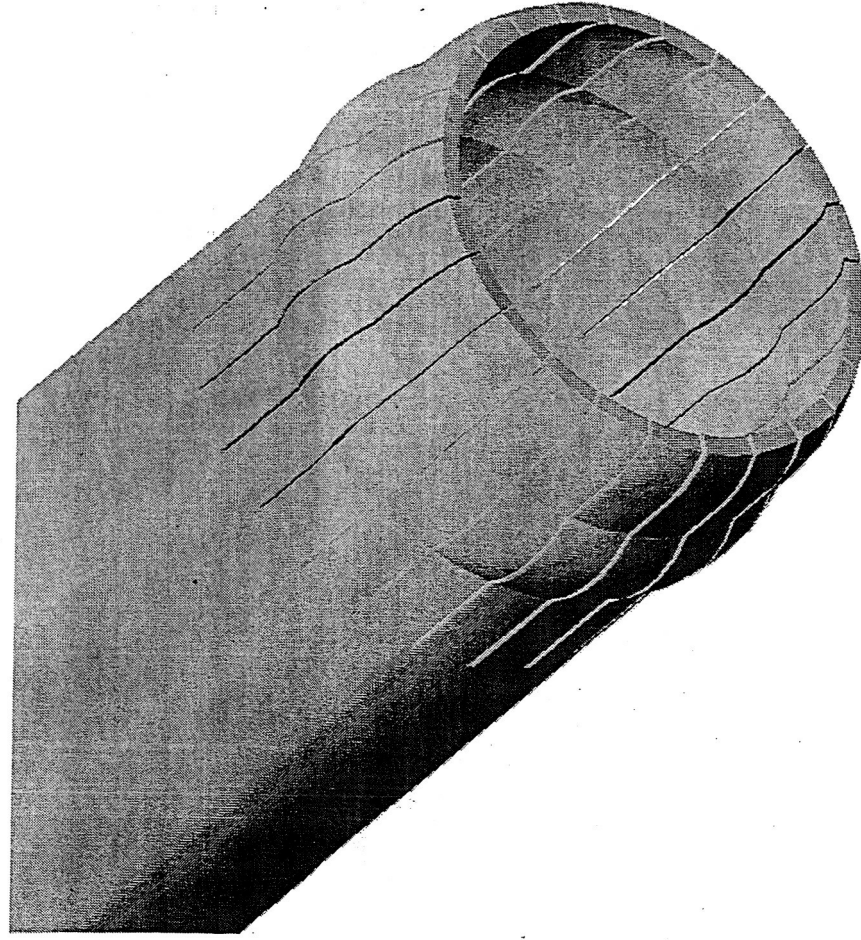
MAJOR CHALLENGE – ROBOTIC PRECISION POSITIONING





BRAZING IN SPACE

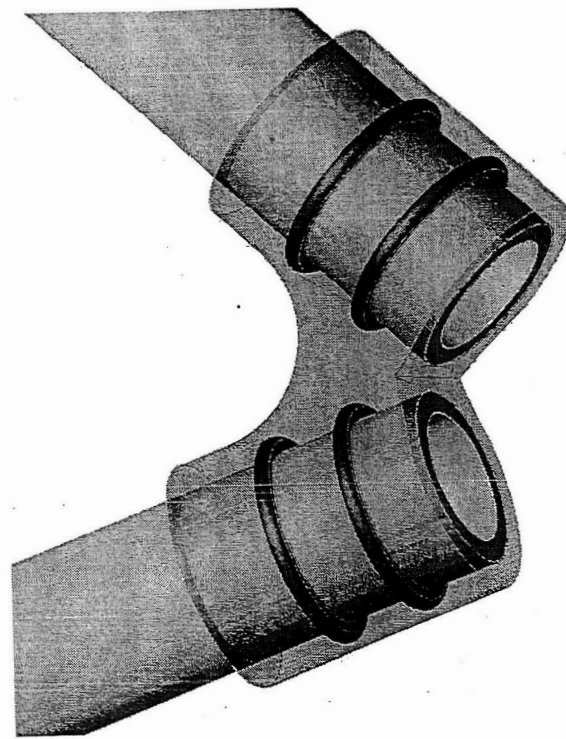
- EFFORT AT GODDARD – robotics



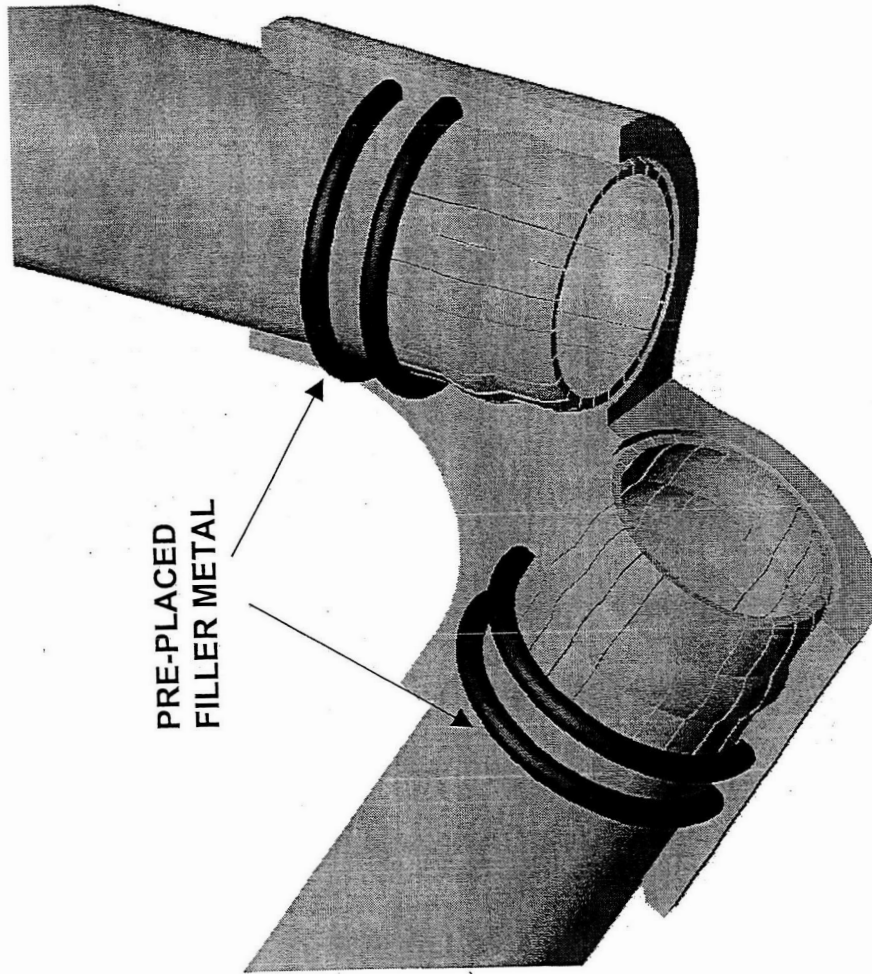
BRAZING IN SPACE



- *EFFORT AT GODDARD – brazeable assembly*



**2-WAY NODE ASSEMBLY
SHOWING THE BRAZE JOINTS
READY FOR BRAZING**



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